The SciDAC Visualization and Analytics Center for Enabling Technology

Future: Research, Software Engineering and Collaborations with Science Stakeholders

Chris Johnson, SCI Institute, University of Utah

VACET, co-PI

Visible Male

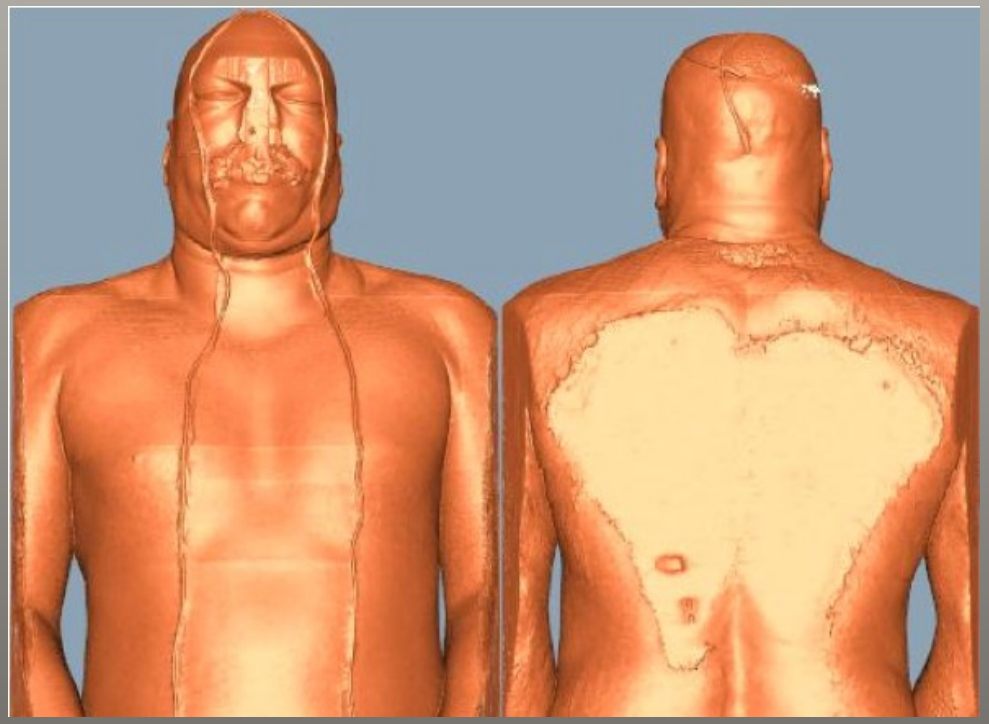
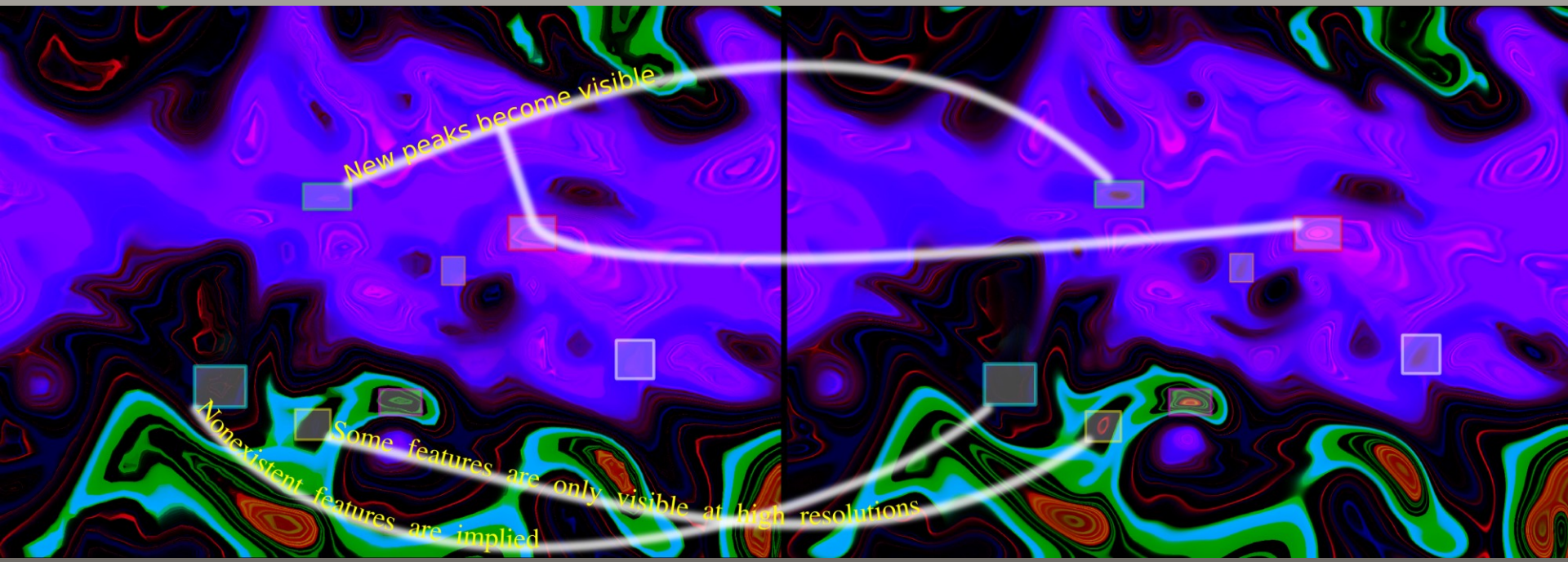


Image Courtesy of Bill Lorensen

Visible Human - High Resolution

The Need for High Resolution Visualization

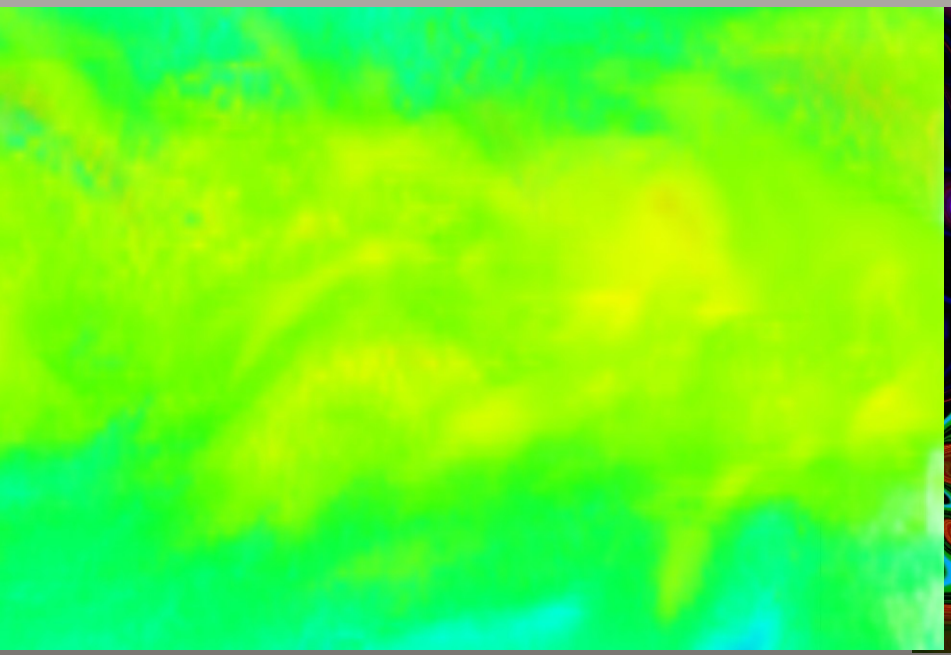
"…the data show for the first time how detailed transport and chemistry effects can influence the mixing of reactive scalars. It may be advantageous to incorporate these effects within molecular mixing models. It is worth noting that at present it is impossible to obtain this type of information any other way than by using the type of highly resolved simulation performed here."
Jacqueline Chen, Sandia National Laboratories



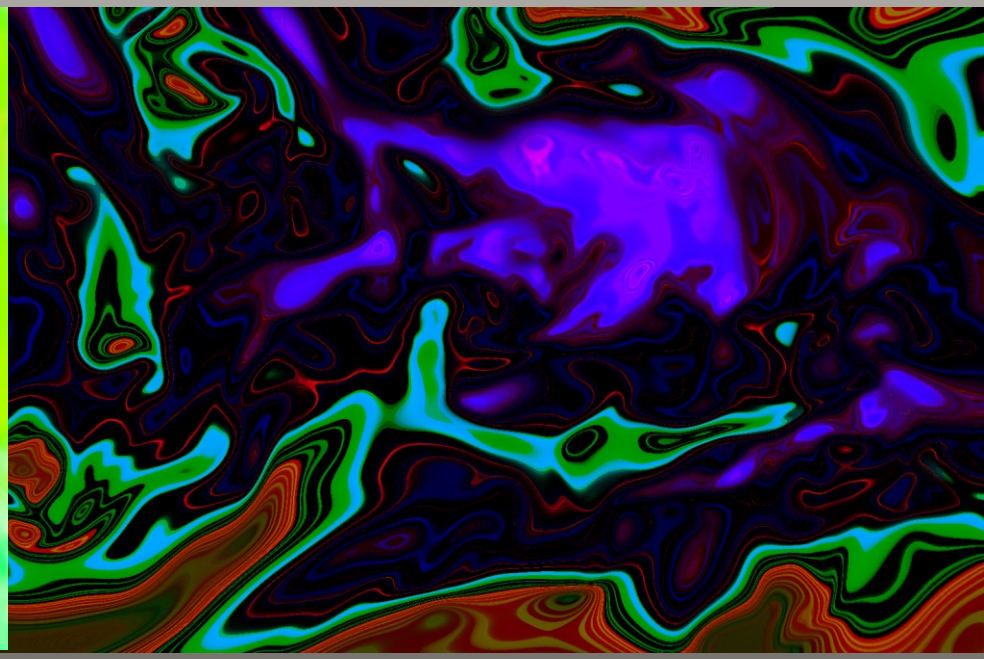
Lower Resolution

High Resolution

Tuvok Volume Rendering



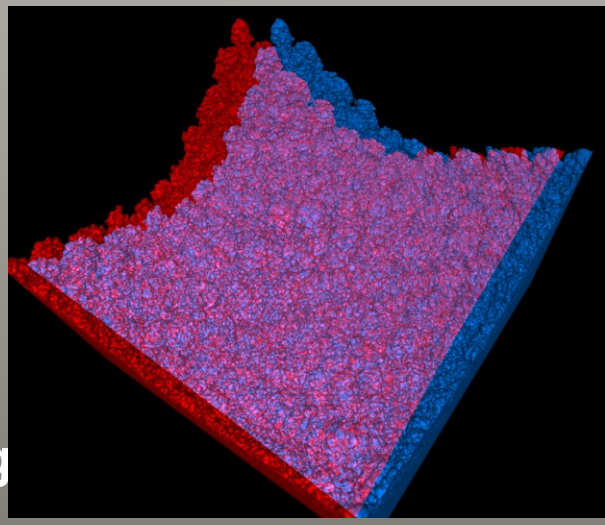
VisIt



Tuvok

Tukov Volume Rendering Engine

Tuvok is a production-quality, high performance volume rendering engine

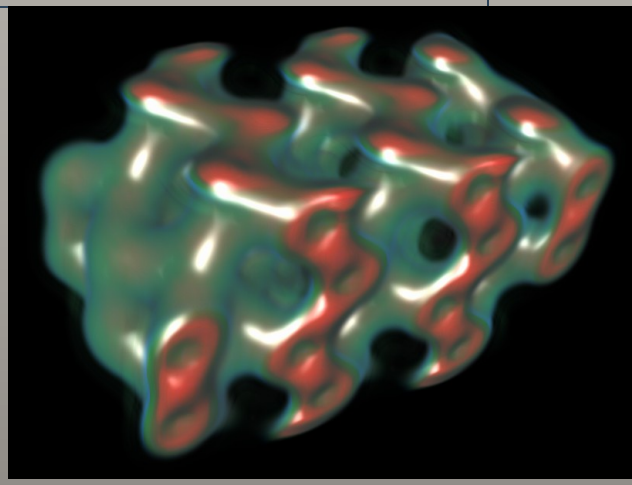


- **Lightweight Modular Design**
- **Up-To-Date Graphics APIs**
  - **OpenGL 2.0**
  - **Direct3D 10 (Direct3D 11)**
  - **Supports wide range of devices (including**
- **Quality**
  - **SBVR & GPU based raycasting**
- **High Performance**
- **Science Impact:**
  - **Enable interactive volume rendering of large-scale high-resolution data.**

Tuvok Demo

Tuvok Volume Rendering Demo

Tuvok Future

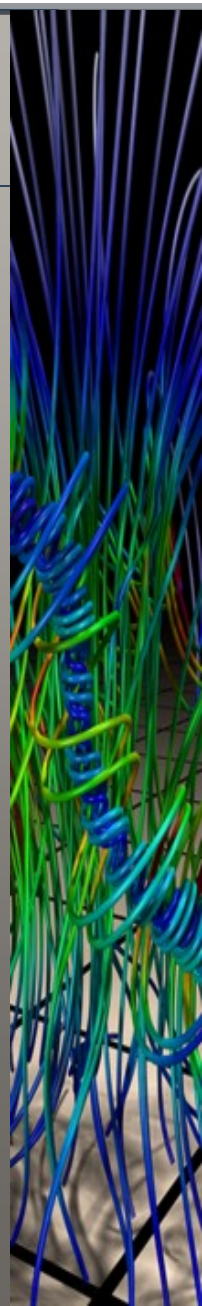


- 1.0 release ‘soon’ (April or May – after the VACET Review)
- HW accelerated, parallel volume rendering
- Basic (SLIVR-level) integration into VisIt (~ 50% done now)
- Parallel rendering on visualization clusters:
  - GLEW/Mesa/VisIt (i.e. "infrastructure") fixes to utilize 100% of a cluster's resources
  - Integration with the IceT compositing path in VisIt [1]
- Delivery: VisIt 2.0, Fall 2009.

[1] From rough calculations, we think we will be able to render the full-res Richtmyer-Meshkov simulation data in real-time on a visualization cluster, such as Lens at ORNL.

Leveraging Our Success

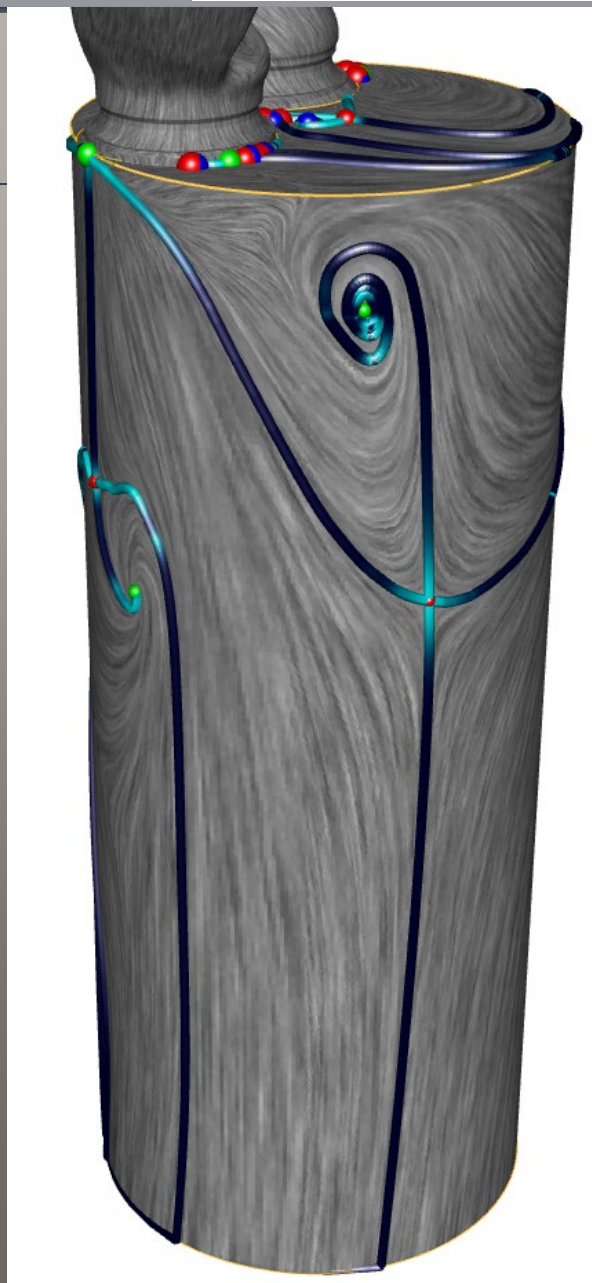
- VACET has successfully brought multiple visualization “products to market”
  - Continue to work with Science applications in adopting VACET technology.
  - Stakeholders are voting with their feet (and data).
- Turning award-winning research into visualization software.
- Leverage our leadership within the SciDAC and visualization communities.
- Continue to realize the vision of a successful SciDAC Center



Future Work

There Is Still Much To Do!

- Cutting Edge Technical Research
- Software Engineering and Deployment of our Current and Future Research
- Working with our Science Stakeholders.



Future Research and Development

- Applying Visualization Methods to AMR
- Parallel Flow Visualization
- Multi-dimensional Techniques
- FTLE Flow Methods
- Uncertainty and Error Visual Representation
- Cluster-based volume rendering (distributed memory) within VisIt
- Higher-level feature extraction from volumetric data
- Multi-field visualization methods
- Topological analysis of particle paths
- Statistical analysis of particle data using model-based clustering methods to identify trends and anomalies

Future Research and Development

- Multi-scale collaborative interfaces accessing shared data sources:
  - Remote interactive analytics
  - Petascale simulation monitoring
- Distributed storage
- Data availability
- Stream processing
- Scalable infrastructure for heterogeneous resources

Future Software Engineering and Deployment

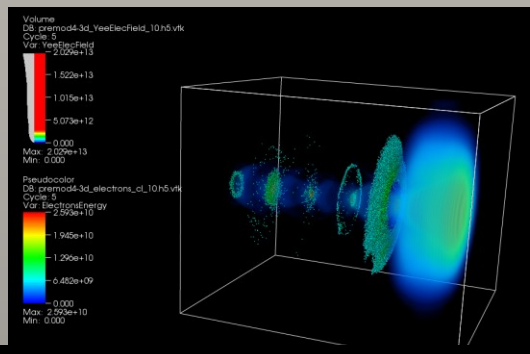
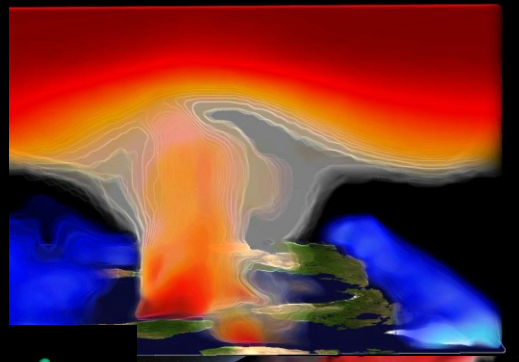
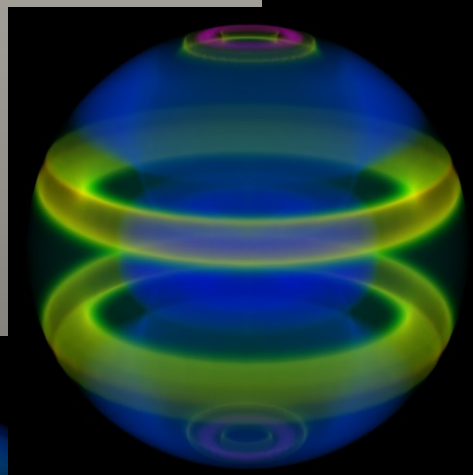
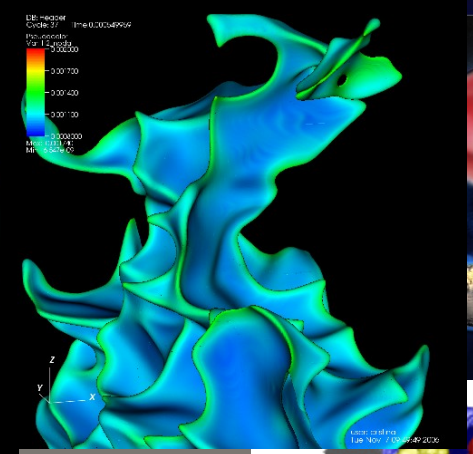
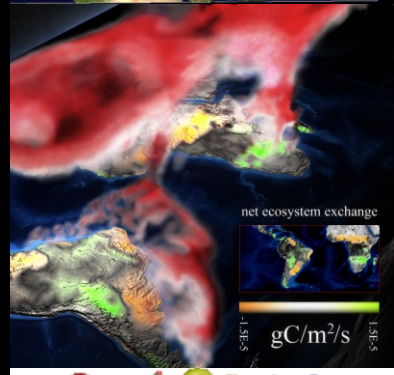
- Improvements for existing customers
  - >100 requests and bug fixes from SciDAC partners.
- Additional partnerships
  - Have only been able to partner with ~50% of groups who have expressed interest.
- Deploy research (e.g. topology, uncertainty vis, volume rendering, and integral curves)
- Implement and deploy advanced data processing algorithms for petascale data.
  - Multi-resolution data exploration, for AMR data and also for Tuvok volume rendering.

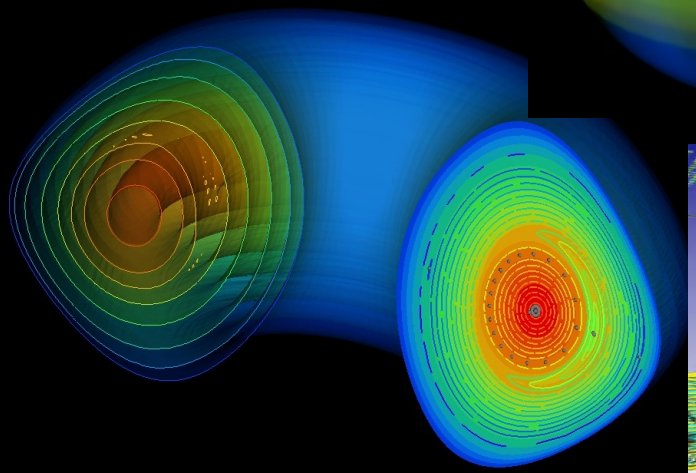
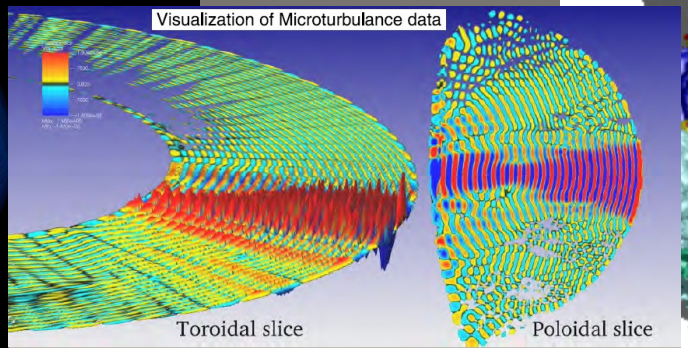
Example Future Software Engineering

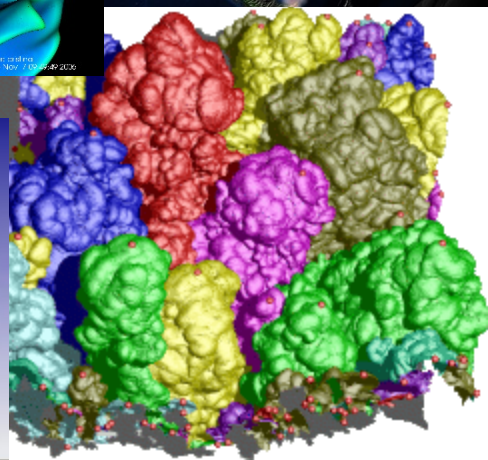
- Parallel reader in VisIt for large data.
- Produced production-quality movies for SciDAC mid cycle review.
- Cross-country remote visualization architecture deployed into customer hand
- Comparative analysis, verification, and validation in VisIt
- Deploy new query based visualization tools utilizing Fast-bit (with the SDM SciDAC Center)
- Enhance parallel coordinate infrastructure to work with the new query based visualization

Future Work with Science Stakeholders

- Accelerator
- Astrophysics
- Climate
- Combustion
- Fusion
- AMR

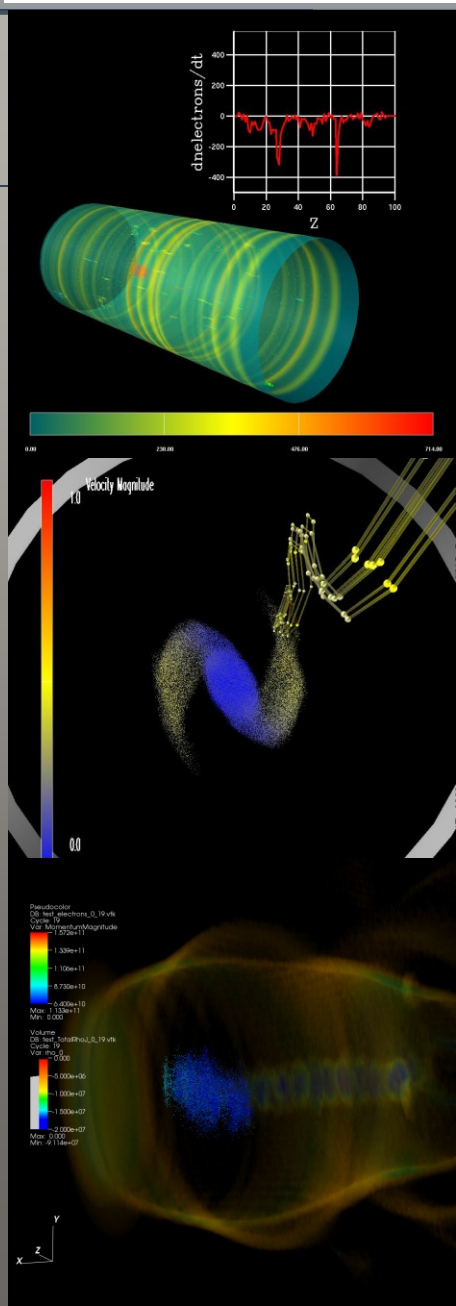








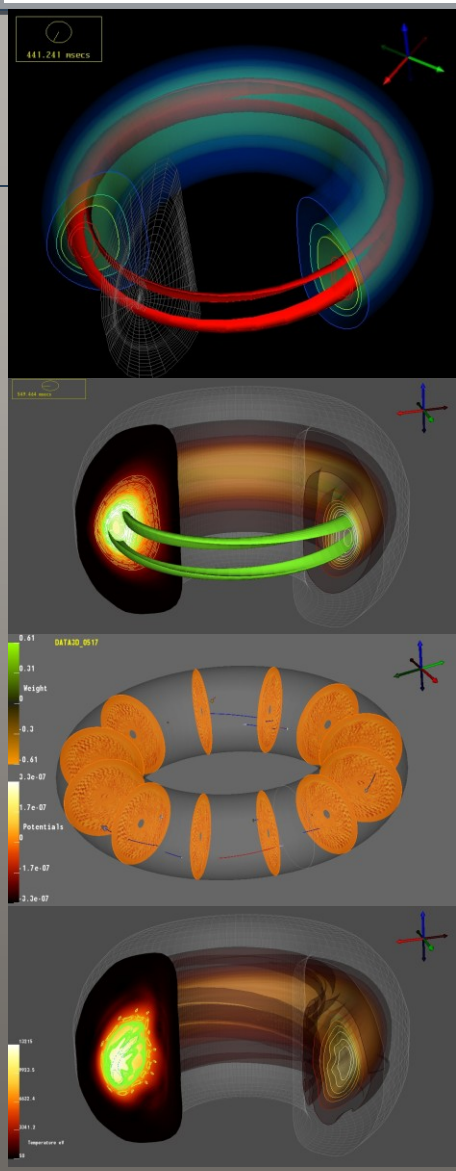
Accelerator Future Work

- Locate and track “interesting particles”
  - Extend FastBit-accelerations for use on field-based data; temporal parallel coordinates (time is another dimension); “named selections” in VisIt – subset selection based upon global identifiers (like particle ID in FastBit); test application of these techniques with ever-larger datasets.
- Perform comparative visualization and analysis showing both raw and statistically summarized fields of subsets of particles and field points



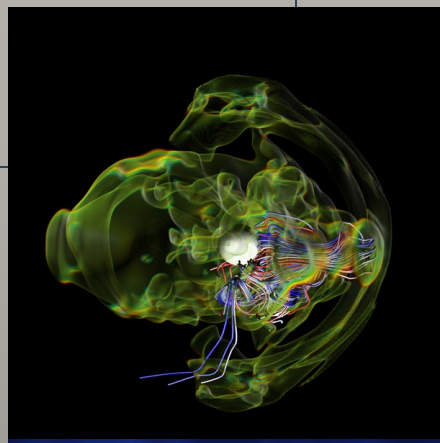
Fusion Future Work

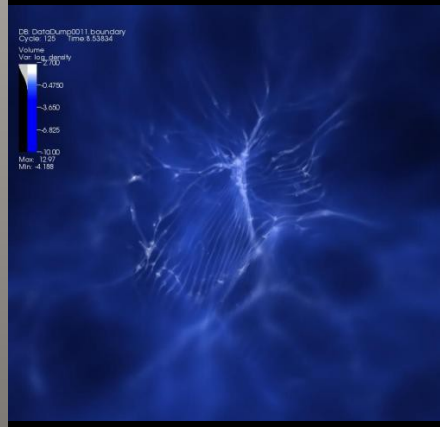
- Analysis of very large numbers of particles from PIC simulations
  - Visual data exploration of multi-billion particles-per-time step data (FastBit+VisIt infrastructure work, better interface for parallel coordinate searches, usability improvements).
- Spatial and temporal feature detection and tracking capabilities for long-duration simulation and experimental data (SAP).
- Comparative visualization and analysis of experimental and simulation data (SAP).
- Multi-field visualization and analysis (SAP)

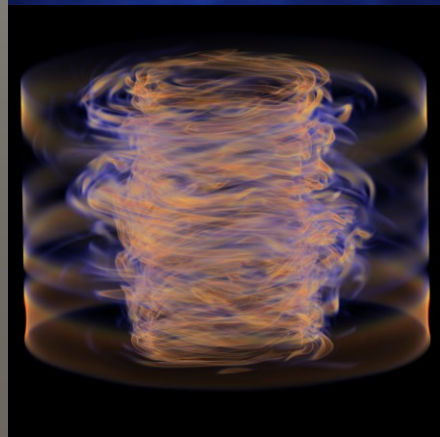


Astrophysics Future Work

- Visualization tools capable of displaying data on AMR grids having vast spatial resolution, from galactic to subplanetary
- New techniques for the effective display of radiation flux data
  - Transition to production-quality, testing with other types of radiation flux data.
- New grid types (e.g., yin-yang grids)
  - Continued I/O performance optimization/tuning, code hardening, production release.

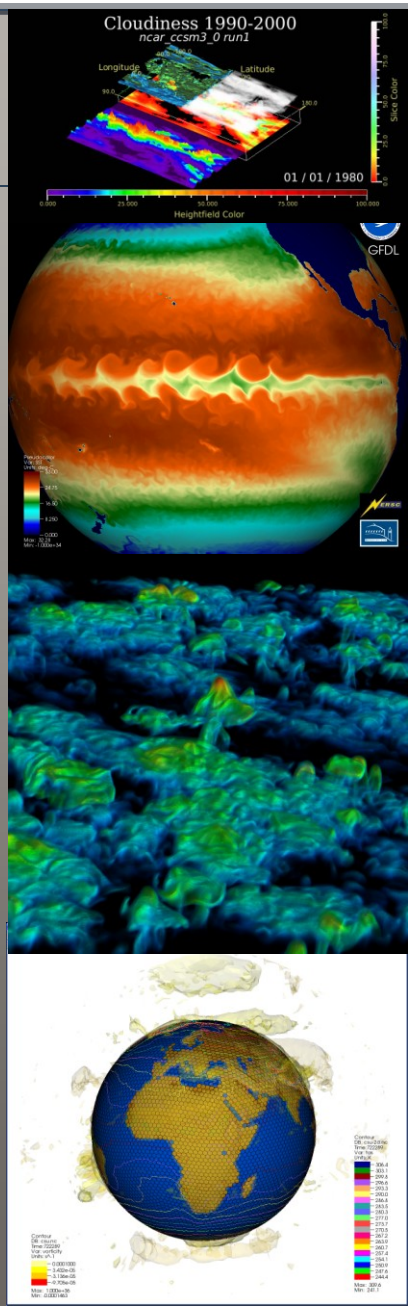






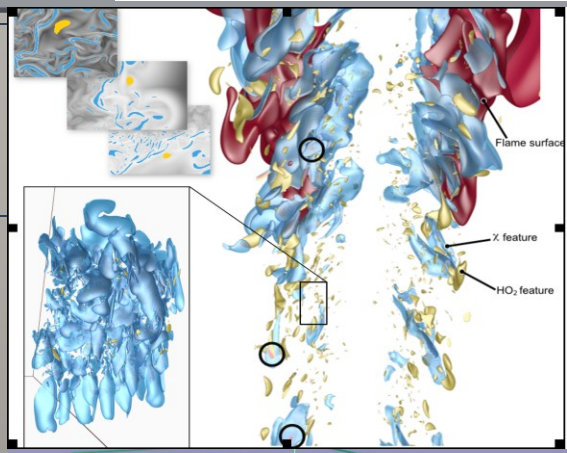
Climate Future Work

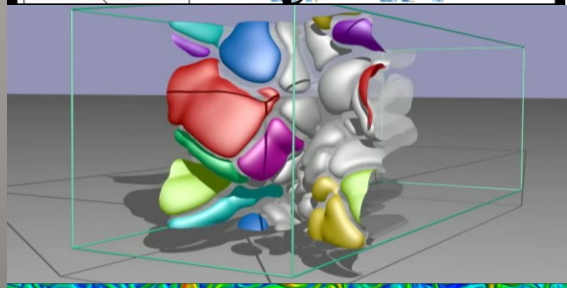
- Create new visualization techniques for tracking uncertainty and characterizing ensemble data
- Workflow/provenance management, improving productivity.
  - Continued integration with VisTrails, software engineering to eliminate OS/platform dependencies, include all of CDATs capabilities in the CDAT package.
- Support for unusual grid types.
  - Parallelize the VisIt plugin, ensure VisIt meets geodesic grid analysis needs, help researchers use VisIt on central and local resources; morton ordering of the geodesic grid for efficient multi-res I/O and vis.

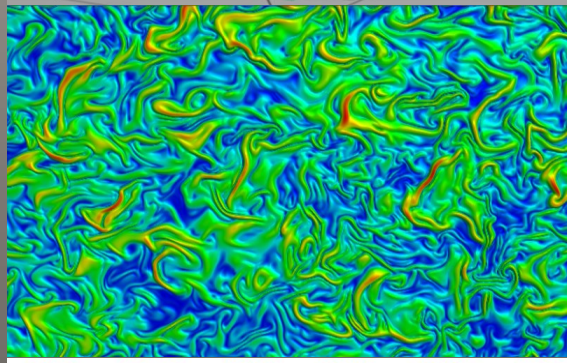


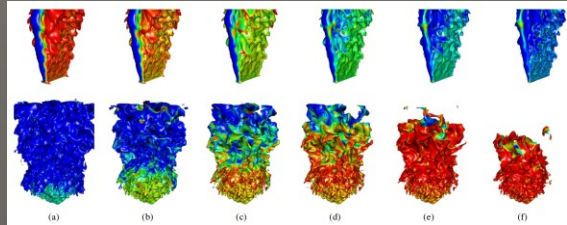
Combustion Future Work

- Full featured, robust visualization applications capable of processing time varying AMR data with effective resolutions of up to 4096^3 and upwards of 80 variables per grid point.
  - Continued “stress testing” as stakeholders continue to generate ever-larger datasets.
- Unified Multi-scale representation of space-time continuum
- Stable feature extraction for time-dependent, high resolution simulation data
- Robust comparison with experimental data
- Robust hierarchical representation of vector fields
- Segmentation of tensor fields









VACET Highlights

Best Paper Award - Steve Parker, James Bigler, Abe Stephens - IEEE Symposium on Ray Tracing 2007.

Best Paper Award - Claudio Silva, Juliana Freire, Carlos E. Scheidegger, Huy T. Vo, David Koop - IEEE Visualization 2007 Conference.

Best Paper Award - H. Wang, C. E. Scheidegger, and C. Silva- IEEE International Conference on Shape Modeling and Applications (SMI) 2008.

Best Paper Award - Understanding the Structure of the Turbulent Mixing Layer in Hydrodynamic Instabilities. D. Laney, P.-T. Bremer, A. Mascarenhas, P. Miller, and V. Pascucci, IEEE Transactions on Visualization and Computer Graphics Vol. 12, No. 5, pp. 1053-1060, 2006.

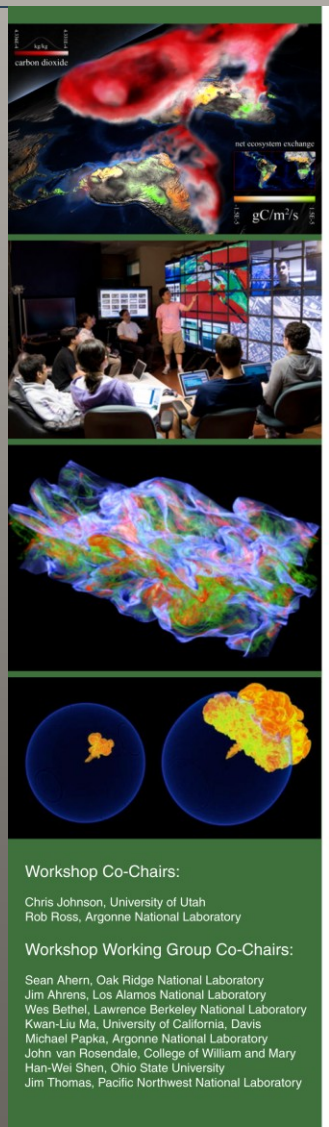
FOR IMMEDIATE RELEASE:

NVIDIA RECOGNIZES UNIVERSITY OF UTAH AS A CUDA CENTER OF EXCELLENCE

University of Utah Latest in a Growing List of Exceptional Schools Demonstrating Pioneering Work in Parallel Computing

SANTA CLARA, CA & SALT LAKE CITY, UT —JULY 31, 2008—NVIDIA Corporation, the worldwide leader in visual computing technologies, and the University of Utah today announced that the university has been recognized as a CUDA Center of Excellence, a milestone that marks the beginning of a significant partnership between the two organizations.

Leadership



Visualization and Knowledge Discovery:

Report from the DOE/ASCR Workshop on Visual Analysis and Data Exploration at Extreme Scale

October 2007

Workshop Co-Chairs:

Chris Johnson, University of Utah
Rob Ross, Argonne National Laboratory

Workshop Working Group Co-Chairs:

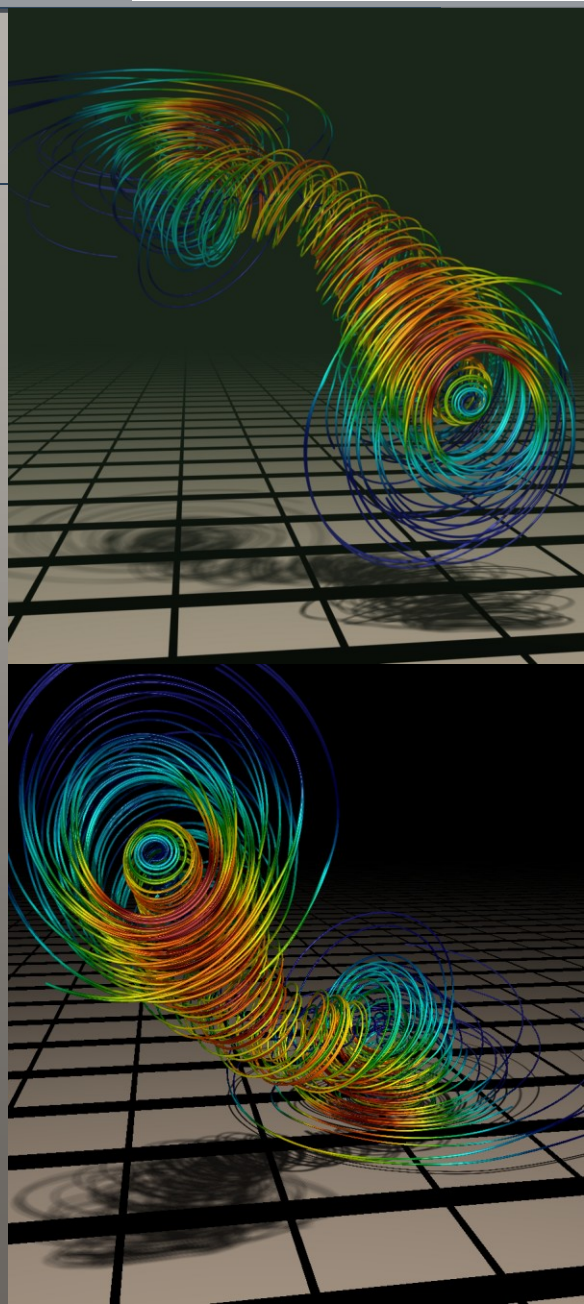
Sean Ahern, Oak Ridge National Laboratory
Jim Ahrens, Los Alamos National Laboratory
Wes Bethel, Lawrence Berkeley National Laboratory
Kwan-Liu Ma, University of California, Davis
Michael Papka, Argonne National Laboratory
John van Rosendale, College of William and Mary
Han-Wei Shen, Ohio State University
Jim Thomas, Pacific Northwest National Laboratory

VACET Mission and Vision

Mission: Leverage sci-vis and analytics software technology as an enabling technology for *enabling scientific insight*.

Vision: Adapt, extend, create, and deploy data understanding technologies for science stakeholders *to enable petascale science.*

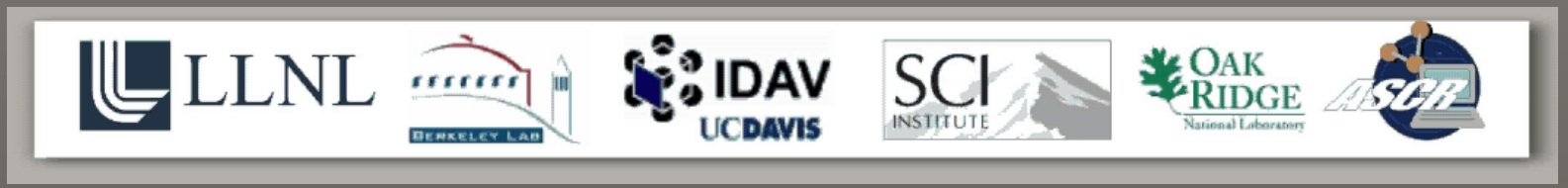
VACET is well positioned to respond to diverse needs/objectives through coordinated R&D, software engineering, and outreach efforts.



Visualization and Analytics Center for Enabling Technologies

A Team of Dedicated Partners

- Lawrence Berkeley National Laboratory
- University of Utah (SCI Institute)
- UC Davis (Institute for Data Analysis and Visualization)
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory



More Information

www.vacet.org

crj@sci.utah.edu

VisTrails - www.vistrails.org

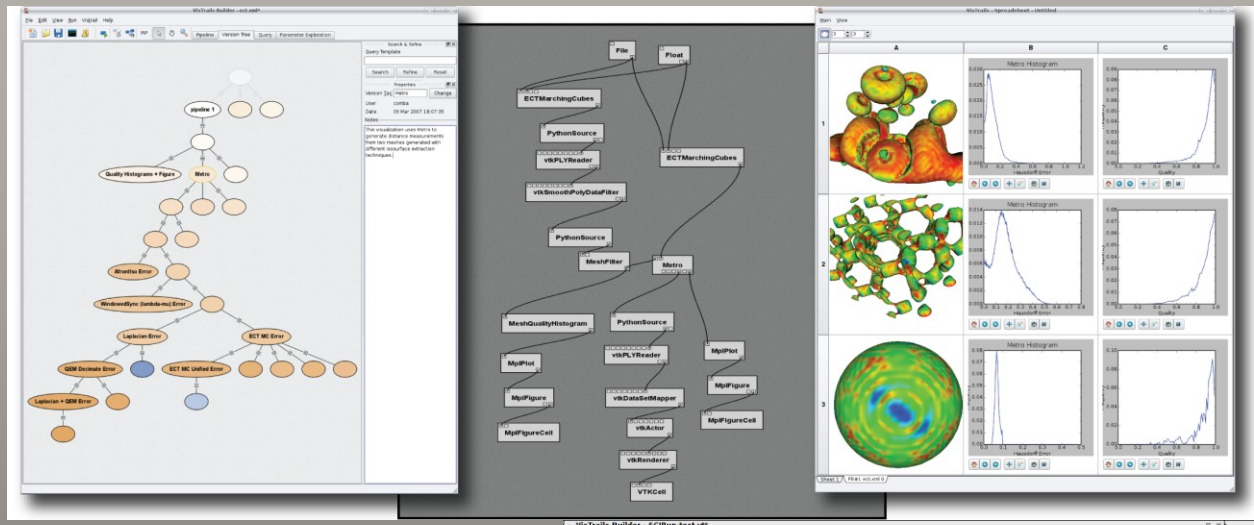
Automatic Provenance Capture

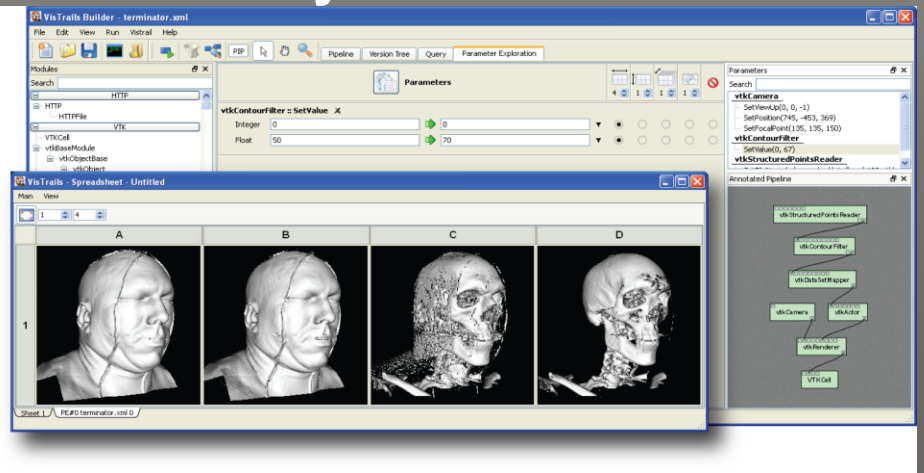
Task Creation by Analogy

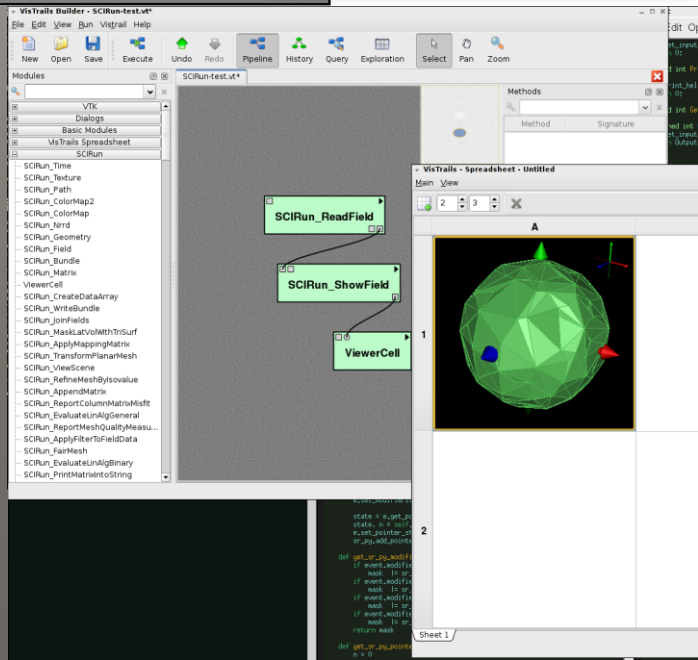
Intuitive Query Interfaces

Support for Collaborative Exploration

Extensibility







•Cosmology at LANL, with J. Ahrens